

## Invited Response to Andrews

Dear Editors:

WE THANK Dr. Andrews for his interest in our past paper and in our recent letter to the Health Physics Journal regarding our adjusted assessment of fossil fuel-derived CO<sub>2</sub> in the atmosphere (Skrable et al. 2022). We believe that our letter to which Andrews refers and the supporting document available through the link therein provide detailed and adequate information to support our position. We provide some additional reinforcing information here in an attempt to clarify our position and respond to Andrews' criticism with reference to items 3 and 4, which he specifies in the beginning of his letter.

Andrews' claim is that the disappearance of fossil-derived CO<sub>2</sub> in the atmosphere is associated with the process of isotope exchange caused by molecular exchange between the atmosphere and CO<sub>2</sub> reservoirs, such that <sup>14</sup>CO<sub>2</sub> concentrations in the atmosphere are increased when fossil-derived CO<sub>2</sub> exchanges with non-fossil CO<sub>2</sub>. An important point to bear in mind is that our assessments are of annual average concentrations of fossil and non-fossil derived CO<sub>2</sub> in the atmosphere. They incorporate any consequences of isotope exchange that have occurred. Our use of the term "non-fossil CO<sub>2</sub>" means that such CO<sub>2</sub> does not contain the anthropogenic fossil component and is basically the same as what existed in the atmosphere prior to the industrial revolution. As we have described earlier, changes from initial values in 1750 of the fossil and non-fossil components are independent of each other.

Annual changes are much less affected by mixing/isotope exchange processes than are longer term assessments. If we look at annual emissions of CO<sub>2</sub> into the atmosphere and evaluate annual increases in our calculated atmospheric CO<sub>2</sub> fossil-derived concentrations, we find fossil changes are much less than what would be predicted from the annual emissions. The values we are using are those from Table 2 of our supporting document (<http://links.lww.com/HP/A230>). The first column in Table 1 contains the years for the chosen interval. Changes expressed in columns are from the end of the first year to the end of the second year. The second column contains our results for the

changes in the fossil-derived CO<sub>2</sub>. The third column contains the fossil CO<sub>2</sub> annual emissions for the respective years of concern and, in parentheses, the equivalent atmospheric concentrations that they represent [GT converted to ppm by multiplying by 0.1278 ppm (GT<sup>-1</sup>)].

The annual changes in our fossil concentrations range from about 18% to 25% of the respective, expected added concentrations from emitted fossil CO<sub>2</sub> in the second year of each interval. If we allowed for mixing/isotope exchange with a 10-y mean life, as noted by Andrews, we could correct the last column of emission values for removal of the fossil component. If we assumed uniform emission throughout the year, such a correction would yield a factor 0.95 by which each value would be multiplied. This would not significantly change our conclusions.

Our position remains that fossil concentrations that we calculate are the result of "non-fossil" CO<sub>2</sub> leaving the reservoirs and entering the atmosphere, thereby causing an increase in atmospheric <sup>14</sup>CO<sub>2</sub> concentrations.

We observe that NOAA<sup>1</sup> has stated that when CO<sub>2</sub> is released to the atmosphere, approximately 50% remains in the atmosphere. This is inconsistent with our conclusion. Of the total of 1,590 GT of fossil CO<sub>2</sub> that has been released to the atmosphere since the start of the industrial revolution, about 20% remains based on our estimation.

Larger reductions in values of the <S(t)> and D14C statistics are required to support claims that the increase, DC(t), in 2018 (t = 268 y) above C(0) in 1750 (t = 0) has been dominated by or equal to the anthropogenic fossil component, <C<sub>F</sub>(t)>, in 2018. For fossil-derived CO<sub>2</sub> to represent 50% of the increase in CO<sub>2</sub> concentration beyond the value at the start of the industrial revolution, S(t) would have to be 11.35 dpm(gC)<sup>-1</sup> instead of 12.18 dpm(gC)<sup>-1</sup>, and D14C would have to be -188.2‰ instead of -128.8‰. In 2018, the fossil component C<sub>F</sub>(t), the increase DC<sub>NF</sub>(t) in the non-fossil component from its initial value of 276.44 ppm in 1750, the total non-fossil component C<sub>NF</sub>(t), and total concentration C(t), then would have values of 64.48, 64.48, 340.9, and 405.4 ppm, respectively. For the fossil component to represent 100% of the increase in the CO<sub>2</sub> concentration beyond the value at the start of the industrial revolution, S(t) would have to be 9.55 dpm (gC)<sup>-1</sup> instead of 12.18 dpm (gC)<sup>-1</sup>, and D14C would have to be -316.9‰ instead of -128.8‰. Also, the fossil component

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<sup>1</sup>See <https://sos.noaa.gov/catalog/datasets/ocean-atmosphere-co2-exchange/#:~:text=When%20carbon%20dioxide%20CO2,certain%20areas%20of%20the%20ocean>. Accessed 11 November 2022.

**Table 1.** Comparison of fossil changes to GT of fossil emissions converted to ppm.

Years for interval	Our fossil change, ppm	Fossil CO <sub>2</sub> emissions, GT and equivalent concentration (ppm)
1950–1951	0.20	6.32 (0.81)
1960–1961	0.26	9.14 (1.17)
1970–1971	0.33	14.8 (1.89)
1980–1981	0.42	18.26 (2.33)
2000–2001	0.69	24.77 (3.17)
2017–2018	1.05	36.22 (4.63)

then would equal the change of 128.96 ppm in the total concentration from the preindustrial value; the change in the non-fossil component concentration would be zero, and the non-fossil component concentration would be equal to the preindustrial value 276.44 ppm. These analyses negate the claims by Andrews and others that most of the CO<sub>2</sub> present in the atmosphere is of anthropogenic origin.

We ascribe the residual fossil-derived CO<sub>2</sub> value that we have estimated to be associated with an increase in a non-fossil-derived component, most likely associated with releases of ocean-stored CO<sub>2</sub> heavily weighted by CO<sub>2</sub> ab-

sorbed during the last glacial period.<sup>2</sup> Of course, there also may have been releases from terrestrial reservoirs.

KENNETH SKRABLE  
GEORGE CHABOT  
CLAYTON FRENCH

*University of Massachusetts  
Lowell Lowell, MA*

## REFERENCE

Skrable K, Chabot G, French C. Components of CO<sub>2</sub> in 1750 through 2018 Corrected for the Perturbation of the <sup>14</sup>CO<sub>2</sub> Bomb Spike. *Health Phys* 123:392; 2022.

<sup>2</sup>See <https://www.ncei.noaa.gov/sites/default/files/2021-11/1%20Glacial-Interglacial%20Cycles-Final-OCT%202021.pdf>. Accessed 11 November 2022.

